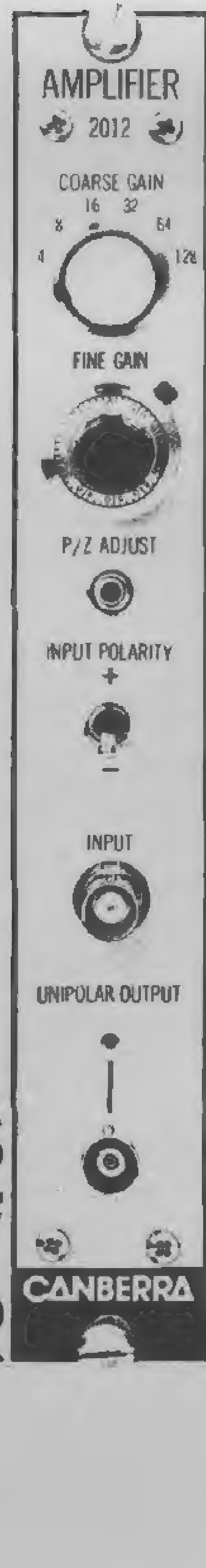
CANBERRA Model 2012 SPECTROSCOPY AMPLIFIER



SPECTROSCOPY AMPLIFIER
MODEL 2012

CONTENTS

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CONTENTS
(Continued)

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Section 1
INTRODUCTION

1.1 GENERAL DESCRIPTION

The Model 2012 Spectroscopy Amplifier was designed using the latest integrated circuit technology to insure a long lifetime of reliable and precise operation. The key to the performance of this instrument is a cleverly designed baseline restorer which, because of its symmetrical characteristics, provides high resolution for both Ge and HP Ge detectors. The reset pulses of the optical preamplifier of the HP Ge detector are no problem to the Model 2012.

Although it is a high performance instrument, the Model 2012 is also very versatile. It has all the characteristics necessary to make it useful with scintillation photomultipliers, gas proportional counters, surface barrier detectors, high purity Ge and of course Ge(Li) detectors. High gain, low noise, selectable time constants, and count rate optimization are several of the more important features designed into the amplifier.

1.2 APPLICATIONS

This section is not intended as a complete survey of applications. It is intended to highlight the most important features of the module and to indicate representative areas where they might be applied.

1.2.1 The NaI(Tl) LIFE TIME SYSTEM

The Model 2012 amplifier is a versatile spectroscopy grade instrument capable of high count rate restoration when used with a variety of detectors. Selectable shaping time constants of 0.5 and 2µsec for use with NaI(Tl), Gas Proportional, Silicon Surface Barrier, Ge(Li), and high purity Germanium detectors, are pushbutton selectable inside the unit.

To obtain excellent count rate performance from this amplifier does not require the adjustment of variable restorer rates and thresholds. A symmetrical restorer automatically compensates for a wide range of count rates. The gain range, temperature stability and non-linearity specifications enable the 2012 to be used in many applications requiring long counting times.

One application diagrammed in figure 1-1 shows the 2012 being used with four separate detector systems, each utilizing the 2012 as the amplifier element, to provide their outputs to a mixer/router which directs each to 1024 channels of MCA memory. The Ge(Li), and Gas Proportional detectors utilize a 2µsec shaping time constant while the Surface Barrier uses 0.5µsec. The NaI Life Time System uses the 2012 Amplifier Unipolar output to time the occurrence of a gamma event from each detector.

The two timing SCA outputs are then translated by a TAC into a pulse spectrum proportional to the time difference between the output signals.

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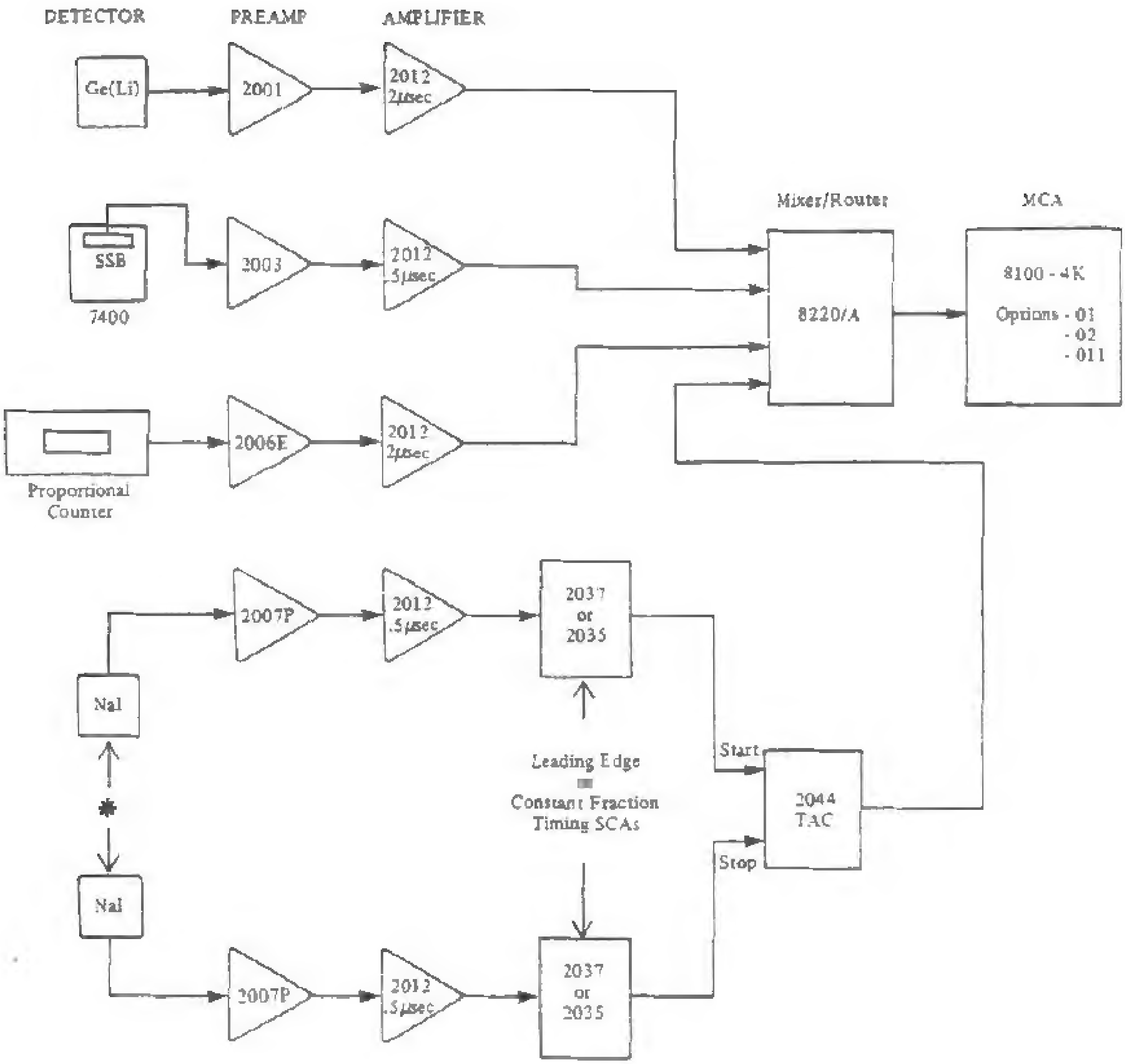


Figure 1-1. NaI(Tl) Life Time System

Section 2
SPECIFICATIONS

2.1 INPUTS

(SIGNAL) INPUT	Accepts positive or negative linear pulses from an associated preamplifier. Input BNC connectors located on front and rear panels. Amplitude: 0 to ± 2 Volts for a linear output; ± 12 Volt max. Rise Time: Less than the shaping time constant selected. Decay Time Constant: 30μseconds to ∞. Input Impedance: Approximately 1K Ohms.

2.2 OUTPUTS

UNIPOLAR OUTPUT	Provides positive-only linear pulses. BNC connectors are located on the front and rear panels. Short circuit protected. Amplitude: + 10 Volts maximum. Timing: Prompt. Shaping: Active filter near-Gaussian shaped. Coupling: DC restored. Factory calibrated for 0 ± 5mVDC. Front Panel Z_{out}: less than 1 ohm or 93 ohms, internally selectable. Rear Panel Z_{out}: 93 ohms.

2.3 PERFORMANCE

GAIN RANGE	Continuously adjustable from X12 to X1280, product of the Coarse and Fine Gain Controls. Coarse Gain Steps are: X4, X8, X16, X32, X64, and X128. Fine Gain Range covers: X3 to X10.
OPERATING TEMPERATURE RANGE	0 to + 50°C.
GAIN DRIFT	Less than ± 0.0075%/°C of full scale.
DC LEVEL DRIFT	Less than ± 50μV/°C.

INTEGRAL NONLINEARITY

Less than ± 0.05% of full scale linear output range.

OVERLOAD RECOVERY

Will recover to within ± 2% of the full scale output in 2 pulse widths for a x 1000 overload with the pole/zero cancellation properly set.

PULSE SHAPING

Semi Gaussian shape: One differentiator, two active integrators, and only one secondary time constant (Approximately 50msec); time to peak is approximately 1.75 times the shaping time constant.

SHAPING TIME CONSTANTS

0.5μsec or 2μsec unipolar shaping; internally switch selectable.

NOISE CONTRIBUTION

With 2μsec shaping time constant, less than 7μv RMS referred to the input for any gain greater than 100.

RESTORER

Time variant (gated): on continuously.

COUNT RATE PERFORMANCE

Unipolar Output, 2μsec shaping.

SPECTRUM BROADENING

FWHM of a Co^{60}, 1.33MeV gamma peak for an incoming count rate of 2kcps to 50kcps and a 9 Volt pulse height will typically change less than 16%.

PEAK SHIFT

The peak position of a Co^{60}, 1.33MeV gamma peak for an incoming count rate of 2kcps to 50kcps and a 9 Volt pulse height will shift less than ± 0.024%.

POWER SUPPLY SENSITIVITY

Supply	AMP DC LEVEL
+ 24V	10mV/Volt
- 24V	10mV/Volt
+12V	6mV/Volt
- 12V	5.5mV/Volt

Supply	AMP GAIN
+24V	0.028 %/Volt
- 24V	0.028 %/Volt
+12V	0.011 %/Volt
- 12V	0.0022%/Volt

2.4 CONTROLS

COARSE GAIN

Front panel rotary switch, 32:1 range in six binary steps.

FINE GAIN

Front panel ten turn precision potentiometer. X3 to X10 range, allowing maximum accuracy and resetability.

POLE/ZERO	Front panel twenty-two turn screwdriver adjustment potentiometer to optimize the Amplifier baseline recovery and overload performance for the preamplifier time constant and main amplifier pulse shaping chosen; range 30μsec to ∞ preamp decay time constant.
INPUT POLARITY	Front panel toggle switch, + (positive), - (negative) positions; only affects signal INPUT connector.
TIME CONSTANTS	Internal push button switch to select shaping time constant of 0.5 or 2.0μsec.

2.5 JUMPER PLUGS

Z_{out}	2 position jumper plug that selects the front panel UNIPOLAR OUTPUT impedance of less than 1 ohm or approximately 93 ohms. Shipped in the low impedance position.

2.6 CONNECTORS TYPES

INPUT	Front and rear panel, BNC.
UNIPOLAR OUTPUT	Front and rear panel, BNC.
TEST POINT	Unipolar Output, front panel, Selectro - SkT-41.
PREAMP POWER	Rear panel, Amphenol #17-10090.

2.7 POWER REQUIREMENTS

+24VDC – 45mA
-24VDC – 50mA
+12VDC – 40mA
-12VDC – 30mA

2.8 PHYSICAL

SIZE	Standard single-width NIM module 1.35 x 8.71 inches (3.43 x 22.13 CM) per TID 20893 (rev.).
NET WEIGHT	2.2 lbs. (1.0 kgs.)
SHIPPING WEIGHT	4.0 lbs. (1.8 kgs.)

Section 3
CONTROLS AND CONNECTORS

3.1 GENERAL

Complete understanding of the purpose of the various controls and connectors is essential for the proper operation of the Model 2012 and it is recommended that this section be read before proceeding with the operation of the module.

3.2 FRONT PANEL (See Figure 3-1)

COARSE GAIN
Six position rotary switch selects gain factors of X4, X8, X16, X32, X64 and X128; multiplied by the FINE GAIN control settings.

FINE GAIN
Ten turn precision potentiometer selects variable gain factor from X3 to X10. Resetability within ±0.03%.

POLE ZERO
22 turn screwdriver adjust potentiometer to compensate for the undershoot caused by the preamplifier fall time constant. Adjustable for preamplifier fall time range of 30μsec. to ∞.

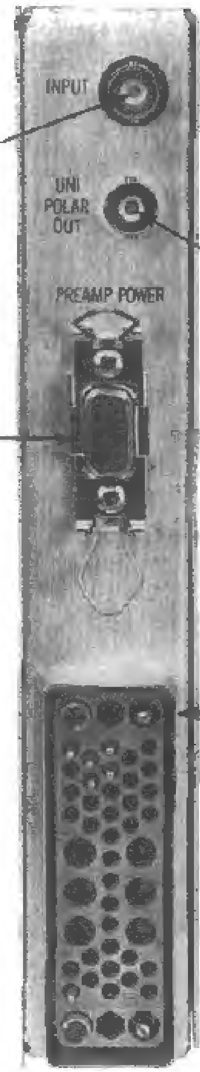
INPUT POLARITY
Toggle switch to set the Model 2012 for the polarity of the incoming preamplifier signal.

INPUT
Accepts positive or negative linear pulses from associated preamplifier. Signal requirements are: Amplitude 0 to ±12 volts maximum; Rise time less than shaping time constant; Decay time constant 30μsec to ∞ Z_{in} approximately 1K ohms.

UNIPOLAR OUTPUT
Provides a positive semi-gaussian Output pulse: active filter pulse shaping. Look under Section 2.2 for signal specifications. Test point is provided, test point output impedance is 470 ohms.

Figure 3-1. Front Panel Controls and Connectors.

3.3 REAR PANEL (See Figure 3-2)



INPUT
Additional input wired in parallel with the front panel signal INPUT BNC connector.

PREAMP POWER
Provides power for any Canberra preamplifier; Model 1708 preamplifier requires a special cable.

PIN	FUNCTION
1	Ground
2	Clean Ground
4	+12VDC
6	- 24VDC
7	+24VDC
9	- 12VDC

UNIPOLAR OUTPUT
Signal specifications are identical to the front panel output except for 93 ohm series - connected output impedance. Use this rear panel output when driving long lengths of interconnecting coaxial cable to prevent distorting the linear signal (oscillations).

MODULE POWER
Connector accepts operating voltages from an AEC Standard NIM bin/power supply such as the Canberra Model 2000.

PIN	FUNCTION
16	+12VDC
17	- 12VDC
28	+24VDC
29	- 24VDC
34	Ground
42	Clean Ground

Figure 3-2. Rear Panel Controls and Connectors.

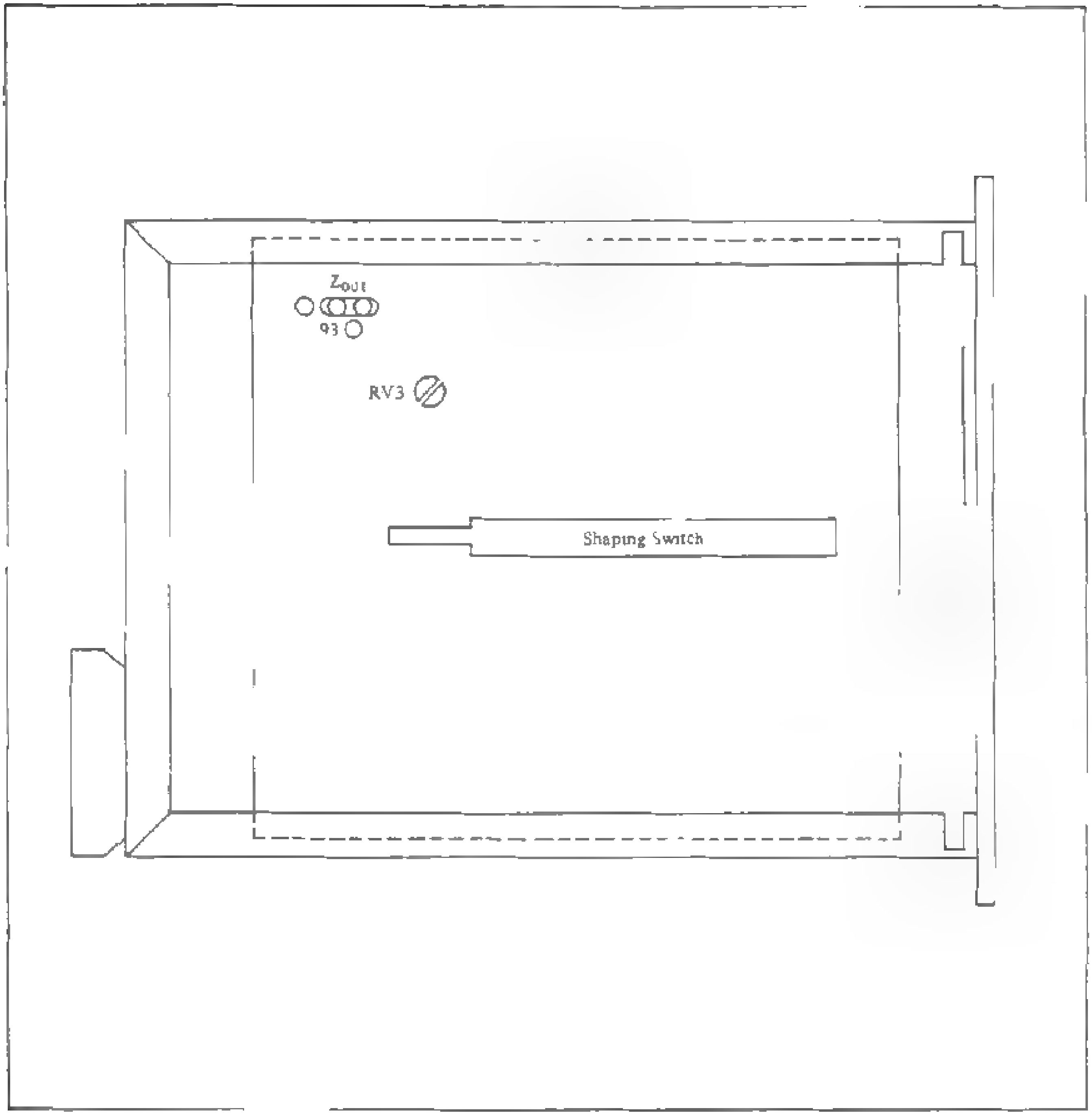


Figure 3-3. Internal Controls, Left Side Cover Removed.

Section 4
OPERATING INSTRUCTIONS

4.1 GENERAL

The purpose of this section is to familiarize the user with the operation of the Model 2012 Amplifier and to check that the unit is functioning correctly Since it is difficult to determine the exact system configuration in which the module will be used, explicit operating instructions cannot be given However, if the following procedures are carried out, the user will gain sufficient familiarity with this instrument to permit its proper use in the system at hand

4.2 SPECTROSCOPY SYSTEM OPERATION

The following instructions apply to obtaining the maximum performance capabilities of the Model 2012 depending on operating and system needs

4.2.1 SYSTEM SETUP

A block diagram of a typical Canberra gamma spectroscopy system is shown in Figure 4-1.

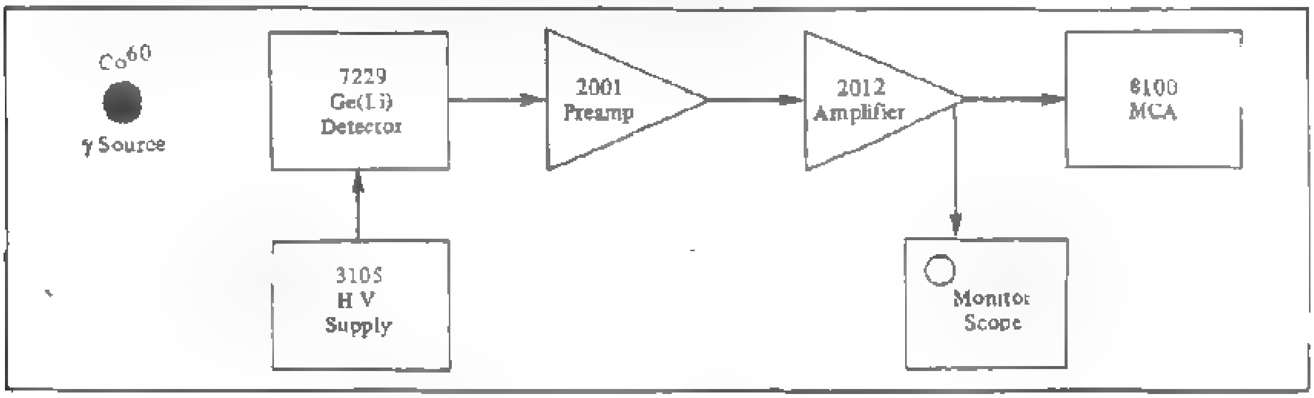


Figure 4-1. Typical Gamma Spectroscopy System.

1. INTERNAL JUMPER PLUGS

   Prior to installation and set up the internal jumper plug should be set to its desired positions See Figure 3-3.

   For the Spectroscopy Amplifier there is the Z_{out} jumper plug which controls the output impedance of the front panel (only) UNIPOLAR OUTPUT The output impedance can be changed from 0 ohms to 93 ohms. The rear panel output has a fixed output impedance of 93 ohms, series connected.

   When using the front panel low impedance output, short lengths of interconnecting coaxial cable need not be terminated. To prevent possible oscillations, longer cable lengths should be terminated at the receiving end in a resistive load equal to the cable impedance (93 ohms for type RG-62/U cable).

   The rear panel 93 ohms output may be safely used with RG-62/U cable up to a few hundred feet. However, the 93 ohm impedance is in series with the load impedance, and a decrease in the total signal range may occur For example, a 50% loss will result if the load impedance is 93 ohms

2 Insert the 2012 into a standard NIM BIN. Preamp power is provided by means of a connector located on the rear panel of the 2012 amplifier. Allow the total system to warm up and stabilize.

3 Set the 2012 controls as indicated below

   a. Shaping: 2 microseconds (Internal)
      COARSE GAIN: 16
      FINE GAIN: 2.2

   This will give approximately a 9 volt output when using a preamp gain of 100mV/MeV and a Co^{60} radioactive source.

   b Set the INPUT POLARITY switch to match the output polarity of the preamp

4 Install a "Tee" Connector on the 2012 Amp Output. Connect one end to the ADC Input on the analyzer. The ADC must be direct coupled for linear input signals to fully exploit the count rate capabilities of the Model 2012 amplifier. All Canberra ADC's are DC coupled.

   Connect the second end of the "Tee" Connector to an oscilloscope and monitor the AMP OUTPUT.

4.2.2 PERFORMANCE ADJUSTMENTS

a. The Pole/Zero is extremely critical for good high count rate resolution. See note 1 on page 4-4. Adjust the radiation source count rate between 2kcps and 25kcps. While observing the AMP OUTPUT on the scope, adjust the Pole/Zero so that the trailing edge of the Gaussian pulse returns to the baseline with no over or under shoots. Figure 4-2a shows the correct setting of the Pole/Zero control, with Figures 4-2b and 4-2c showing under and over compensation for the preamplifier decay time constant. Notice some small amplitude signals with long decay times in Figure 4-2a. These are due to charge trapping in the detector and cannot be corrected by the Pole/Zero control.

b Pole Zero adjustment using a square wave and preamp test input. See Note 2 on page 4-4

   Driving the preamp test input with a square wave, will allow a more precise adjustment of the amplifier P/Z.

   1 The Amplifier's controls should be basically set for its intended application: coarse gain, shaping, input polarity.

   2. Adjust the square wave generator for a frequency of approximately 2kHz.

   3. Connect the Function Generator's output to the Preamp's Test Input.

   4. Remove all radioactive sources from and near the detector.

   5 Set the scope's Chan 1 vertical sensitivity to 5 Volts/Div., and adjust the main time base to 0.1msec/Div. Monitor the 2012's UNIPOLAR OUTPUT and adjust the function Generator's amplitude control (attenuator) for output signals of ± 8 volts

   Note: Both positive and negative Gaussian pulses will be observed at the output

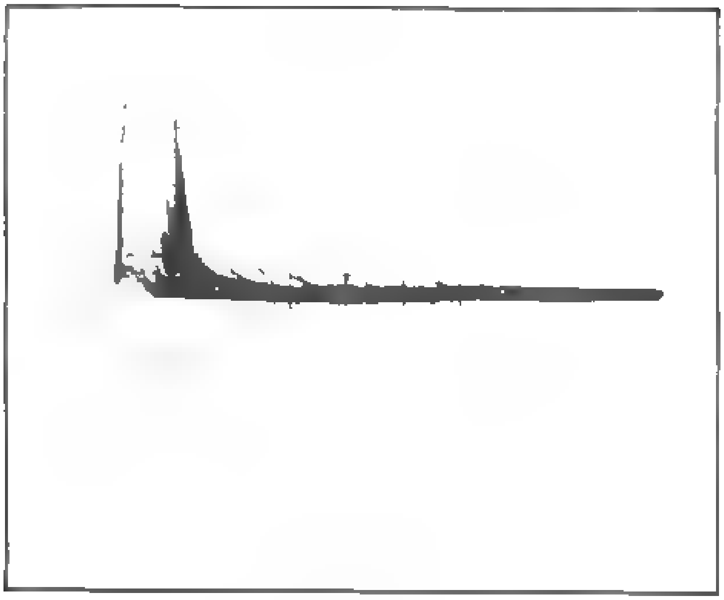


Figure 4-2a
Correct P/Z Compensation

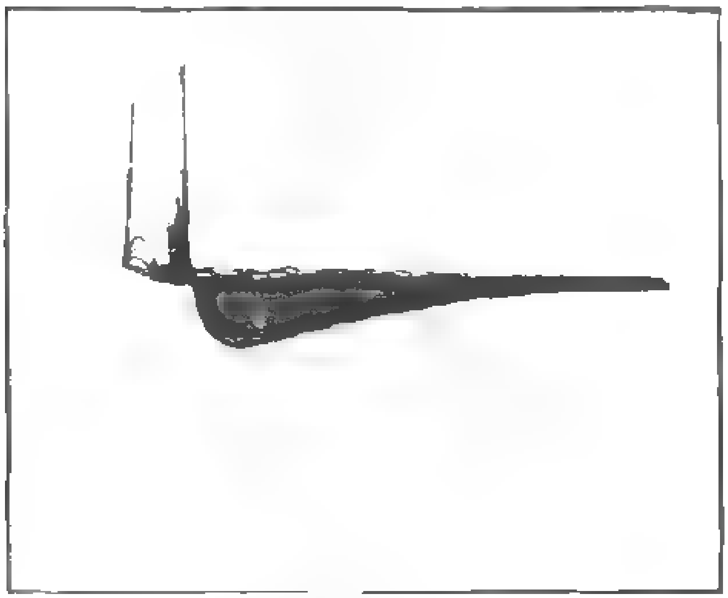


Figure 4-2b
Undercompensated P Z

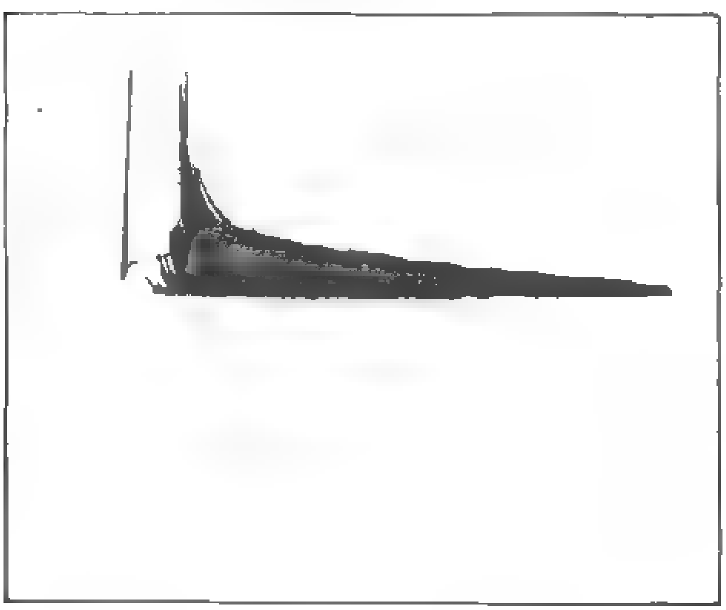


Figure 4-2c
Overcompensated P Z

Oscilloscope
Vert 50mV/Div
Horz 10μsec/Div

Source Co^{60}
1 33meV Peak 7V Amplitude
Count Rate. Approx 3 kcps
Shaping 2μsec

Figure 4-2. Pole/Zero adjustment with a Live source (Co^{60})

6 Reduce the Scope vertical sensitivity to 50mV Div See Note 1 below

Figure 4-3a shows the correct setting of the P/Z control. Figures 4-3b and 4-3c show under and over compensation for the preamplifier decay time constant

As illustrated in Figure 4-3a, the UNIPOLAR OUTPUT signal should have a clean return to the baseline with no bumps overshoots or undershoots

c HPGe detectors and Si Systems with Optical Feedback Preamps.

For normal Si systems the P Z is usually set at ∞ , full counter clockwise However on some systems the P/Z may need to be slightly tweaked for optimum overload recovery to the preamp's reset pulse

NOTE 1

At high count rates the P Z adjustment is extremely critical for maintaining good resolution and low peak shift For a precise and optimum setting of the P Z a scope vertical sensitivity of 50mV Div should be used. Higher scope sensitivities can also be used but result in a less precise P Z adjustment However, scopes such as the Tektronix Models 453, 454, 475 and 476 will overload for a 10 volt input signal when the vertical sensitivity is set for 50mV Div Overloading the scope input will distort the signal's recovery to the baseline Thus the P/Z will be incorrectly adjusted resulting in a loss of resolution at high count rates To prevent overloading the scope a clamping circuit, such as the one illustrated in Figure 4-4, can be used at the scope input

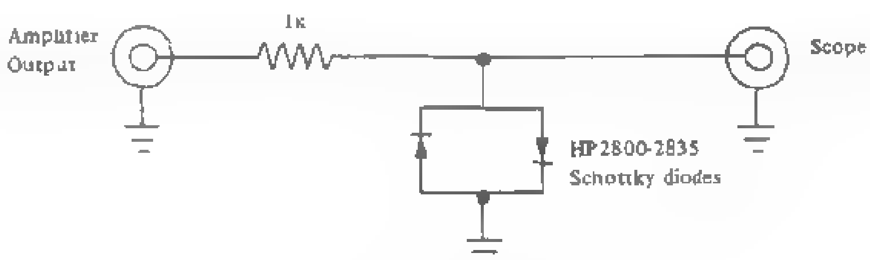


Figure 4-4 Scope Input Clamp

NOTE 2

When adjusting the P Z using the square wave technique, the calibration square wave generated by the oscilloscope can be used Most scopes generate a 1kHz square wave used to calibrate the vertical gain and probe compensation. Connect the scope CALIBRATION Output thru an attenuator to the preamp test Input and repeat 4.2.2b steps 1 thru 6.

d. AMP DC LEVEL

The AMP OUTPUT dc level is factory calibrated to ± 1 millivolt. The adjustment is made internally by RV3 and covers a range of ± 100 millivolt. See the checkout and maintenance section for further information.

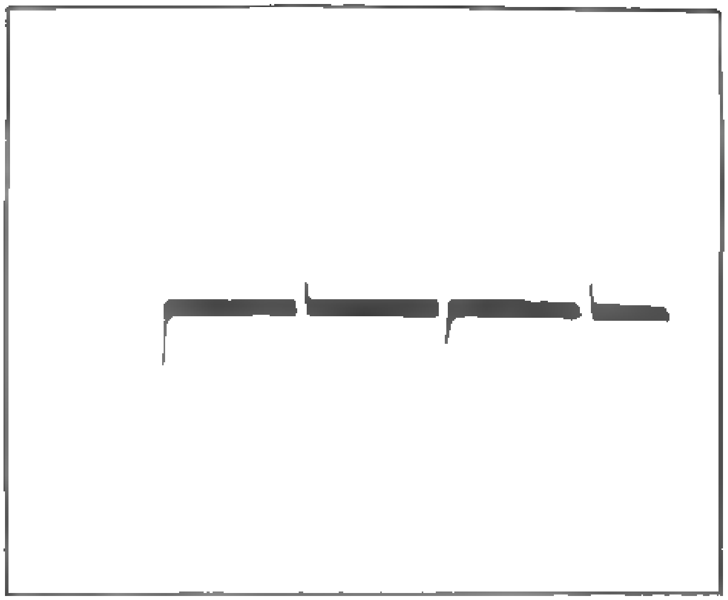


Figure 4-3a
Correct P Z Compensation

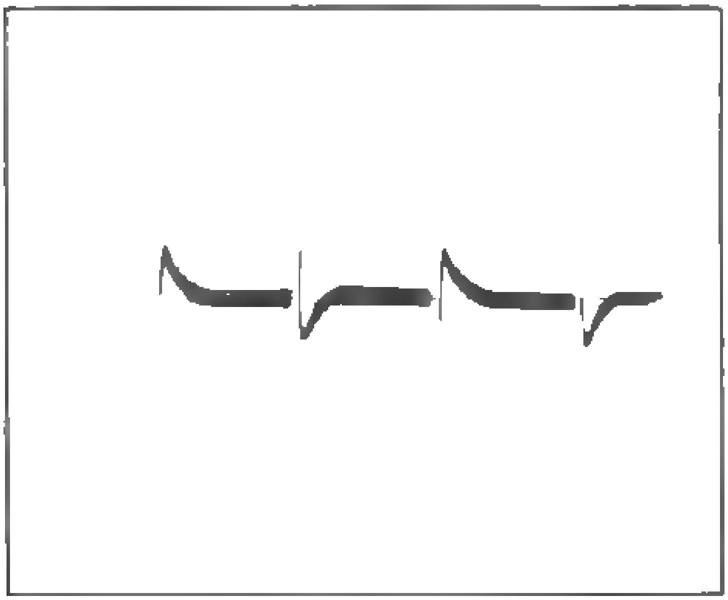


Figure 4-3b
Undercompensated P/Z

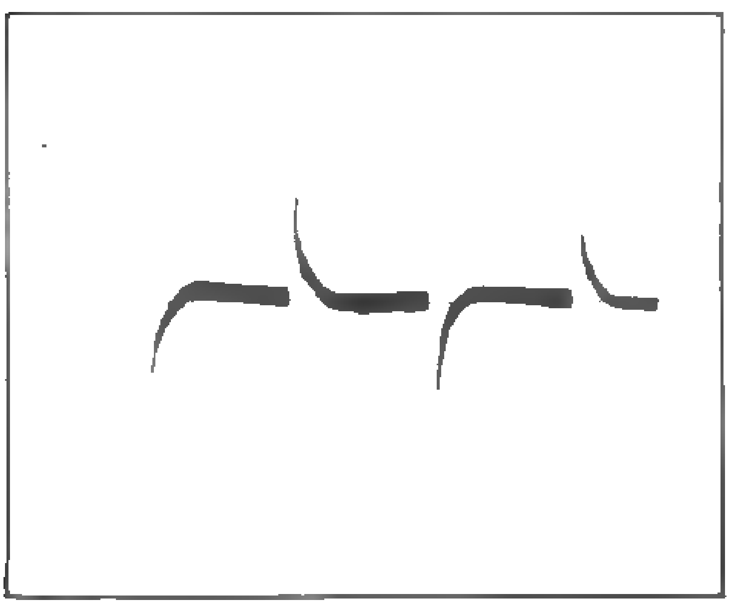


Figure 4-3c
Overcompensated P/Z

Oscilloscope
Vert 50mV/Div
Horz 0.2μsec/Div

Figure 4-3 Pole/Zero Adjustment using square wave pulse and preamp test input

e MCA CONTROLS

To get optimum resolution, the Lower Level Discriminator on the ADC should be set just above the noise so that the effects of pile-up are minimized

4.2.3 RESOLUTION VERSUS COUNT RATE AND SHAPING

The 2μsec shaping time constant is optimum for Ge(Li) detector systems over a wide range of incoming count rates For high resolution larger shaping time constants offer a better signal to noise (S N) ratio, resulting in better resolution However as the count rate increases, the effects of pile up will degrade the resolution much sooner The optimum shaping time constant depends on the detector (such as its size configuration and collection characteristics), preamplifier and incoming count rate Below is a list of optimum shaping time constants for some other common detectors

Detector	Optimum Shaping (μsec)
Scintillation Photomultiplier	0 5
Gas Proportional Counters	0 5 or 2
Silicon Surface-Barrier	0 5 or 2
Cooled Silicon	8 or 12

The Model 2012 is normally factory set for 0.5μsec or 2μsec shaping time constants However the shaping time constants can be changed to 8 and 12μsec to be compatible with cooled Silicon detectors. Change the components as follows.

1. Change C1 from 560pf to 9100pf
2. Change C2 from 1600pf to 560pf
3. Change R1 from 19 1K ohms to 22 6K ohms
4. Change R2 from 52 3K ohms to 11K ohms
5. Change C3 from 130pf to 2000pf
6. Change C4 from 360pf to 1300pf
7. Change C5 from 200pf to 2400pf
8. Change C6 from 510pf to 1600pf
9. Change C25 from 47pf to 1000pf
10. Change C26 from 200pf to 510pf

All resistors are RN60C's and capacitors are 1% silver mica.

4.3 RESOLUTION DESTROYING INTERFERENCES

a Vibration transmitted to the detector and cryostat This can be through the floor or mounting, as well as direct audio coupling through the air Vibration isolators in the mounting and sound absorbing covers around the detector can reduce this problem.

b The close proximity of a radio station can be picked up by the "dipstick" of the cryostat Good contact between the dipstick and the cryostat can often help solve this problem Beware of grounding the cryostat and dipstick as this may increase power line frequency (50 or 60 cycle) ground loops

c Ground Loops Power line frequency interference can be caused by long cable connections between the detector, preamplifier and shaping amplifier. There is no general solution for this problem. As a first step, the preamp should use the power supplied by the main shaping amplifier. Second, the system should have a single point house ground. For example on a general system connect the NIM Bin to house ground via the third prong on the AC Line Cord Isolate all other equipment requiring AC Voltage from the house ground. Connect all the chassis in the system to the grounded NIM Bin using heavy braided wire

d High voltage power supplies Generally, the H V P S should float from power line ground with the only ground being made at the preamplifier through the high voltage connecting cable.

e Analyzer EMI. If the detector is located within 10 to 15 feet of a multichannel analyzer containing a ferrite core memory It can receive EMI (electro-magnetic interference) This is due to high memory core currents during the memory cycle of the analyzer. The only practical cure for this problem is to operate the analyzer in the "Live" Mode of accumulation. In this way, the memory cycle only operates while no signal is being analyzed

f. Is the output of the spectroscopy amplifier and the input of the ADC fully compatible? This may seem an obvious consideration, but it is commonly overlooked The shaping time constant as stated on the spectroscopy amplifier is *not* the rise time of its output signal In the case of a Model 2012 Amplifier, the time-to-peak of the AMP OUTPUT is . 75X the shaping time constant Therefore, a 12μsec shaped pulse requires 21μsec to reach full amplitude Many analyzers will not handle this instead of analyzing the peak of the signal, they analyze a percentage of the rise time

g. Amplifier parasitic oscillations. If the cable connecting the front panel outputs of the amplifier to the ADC exceed 10 to 20 feet in length, oscillations can occur The cure is to use RG-62/U cable (93 ohm impedance) and terminate the ADC end of the cable with a 93.1 ohm metal film resistor Alternatively, the 93 ohm output impedance of the amplifier can be used with no terminator

Section 5
CHECKOUT AND MAINTENANCE, CALIBRATION

5.1 EQUIPMENT REQUIRED

a. Oscilloscope (Tektronix Models 453, 465, 581 or equivalent)

b. Digital Voltmeter (< 0.1% Full Scale Accuracy)

c. Resistive Voltmeter Probe (200 to 1K ohms in series)

d. Current Meters

e. Noise Meter (Model HP-400H or equivalent)

f. Pulser - Model 1407 (either standard or modified for 20V Out)

g. NIM Power Supply

5.2 NIM VOLTAGE CHECK

With a DVM, measure the NIM Power Supply voltages and adjust if they are outside of the following ranges.

+24V	+23.98	to	+24.02V
-24V	-23.98	to	-24.02V
+12V	+11.99	to	+12.01V
-12V	-11.99	to	-12.01V

5.3 CURRENT MEASUREMENTS

a. Apply power to the Model 2012 and measure the currents. They should be within the following ranges

+24V	35 to 55mA
+12V	30 to 50mA
-12V	20 to 40mA
-24V	40 to 60mA

NOTE: A greater deviation in currents indicates a faulty unit. Gross errors would probably be due to faulty or reversed capacitors, shorted or open transistors, etc.

b. Replace the current meters with a power cable

5.4 DC LEVEL CHECKS AND ADJUSTMENTS

5.4.1 INITIAL SETUP

a. Set the Model 2012 COARSE GAIN to 4.

b. Connect a 93 or 100 ohm terminator to the rear panel INPUT

5.4.2 AMPLIFIER DC LEVELS

a. Measure the level at TP4: It should measure -150 to +150mVDC

b. Monitor TP1 and adjust RV3 for - 1 to + 1mVDC

5.4.3 RESTORER THRESHOLD DC LEVELS

a. Measure the levels at the following points

A2 pin 3: - 80 to - 120mV
A2 pin 2: 0 to - 320mV

b. Measure the level at A2 pin 6 versus COARSE GAIN. The level should be be within the range indicated below.

COARSE GAIN	A2 Pin 6
4,8	- 140 to + 15mV
16, 32	- 120 to + 30mV
64	- 100 to + 60mV
128	- 50 to + 120mV

5.5 AMPLIFIER OPERATIONAL CHECKS

5.5.1 INITIAL SETUP

a. Set the controls as follows.

Model 2012 Controls

COARSE GAIN:	4
FINE GAIN	10
SHAPING:	2μsec (internal)
POLE ZERO	Fully CCW
INPUT POLARITY	POS

Model 1407 Controls

PULSE HEIGHT	5.4 (2.7 if modified 1407)
NORMALIZE	10
POS/NEG:	POS
60Hz/OFF/90Hz:	90Hz
RISE TIME	MIN
FALL TIME:	400μsec
ATTENUATION:	x10

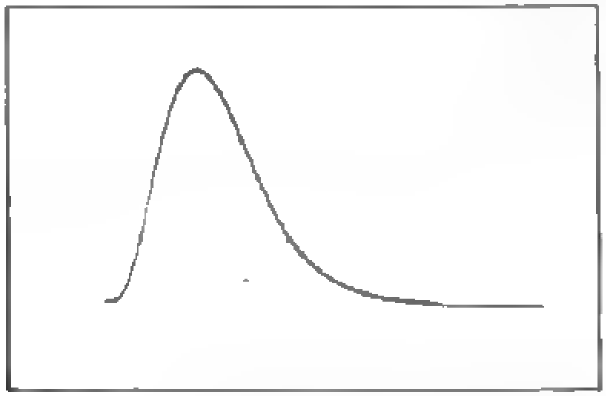
b. Connect a 93 or 100 ohm terminator to the 2012 rear panel INPUT.

c. Connect the Model 1407 ATTEN OUTPUT to the 2012 front panel INPUT with RG-62 coax cable.

d. Connect the Model 1407 NORMAL OUTPUT to the EXT TRIG input of the scope. Set the scope triggering to EXT, +.

5.5.2 OUTPUT

a Connect the UNIPOLAR OUTPUT to the scope with RG-62 coax cable, using a "T" connector at the scope. You should observe the Gaussian shaped pulse shown in Figure 5.1.



Amplitude 9 to 11V

Figure 5.1. AMP OUTPUT (2V/div.,2μsec/div.)

b Adjust the Model 1407 PULSE HEIGHT until the UNIPOLAR OUTPUT amplitude is + 9.9 to 10.1v.

c Place jumper plug J4 in the 93 ohm position. Connect a 93 ohm terminator to the "T" connector at the scope input. The amplitude of the pulse should be + 4.8 to 5.2v. Remove the 93 ohm terminator.

d Place Jumper Plug J4 in the 0 ohm position.

e Connect the 93 ohm terminator, the amplitude should not decrease by more than 100mV. There should be no discernible distortion in the pulse shape. Remove the terminator.

f Set the Model 1407 ATTENUATION to X1. The UNIPOLAR OUTPUT pulse should be clamped at + 11.5 to 12.5v.

g. Set the Model 1407 ATTENUATION to X10.

5.5.3 POLE ZERO ADJUSTMENT

a Set the Model 1407 FALL TIME to 50μsec.

b Observe the UNIPOLAR OUTPUT on the scope and adjust the P/Z control so that the tail of the Gaussian pulse returns to the baseline as fast as possible with NO under or overshoot as in Figure 5.2.

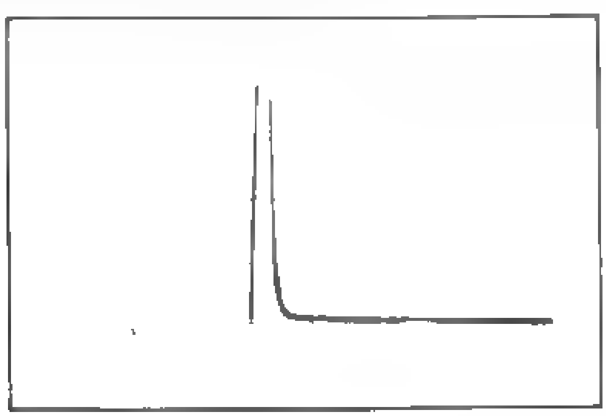


Figure 5.2 Pole Zero Adjustment, AMP OUTPUT (5V/div., 20μsec/div.)

5.5.4 COARSE AND FINE GAIN CONTROLS

a. Set the Model 2012 COARSE GAIN to 128; FINE GAIN to 10.0

b Connect the AMP OUTPUT to the scope with RG-62 coax cable

c Set the Model 1407 ATTENUATION to X500 Adjust the Model 1407 PULSE HEIGHT until the output pulse attains an amplitude of + 9.9 to + 10.1V

d Measure the unipolar output amplitude for each COARSE GAIN setting The amplitudes should be within the range indicated below

COARSE GAIN	UNIPOLAR OUTPUT AMPLITUDE
128	9.9 to 10.1V
64	4 75 to 5.2V
32	2 35 to 2.65V
16	1.15 to 1.35V
8	0 59 to 0.66V
4	0.29 to 0.34V

e. Set the Model 2012 COARSE GAIN to 128

f Monitor the UNIPOLAR OUTPUT on the scope and turn the 2012 FINE GAIN Control to minimum The amplitude of the output pulse should decrease to +2.7 to +3.3V.

g. Return the FINE GAIN to maximum

5.6 SHAPING CHECKS

a. Set the Model 2012 to 2μsec. shaping

b Set the Model 1407 ATTENUATION to X500 Adjust the Model 1407 PULSE HEIGHT until the output pulse attains an amplitude of 9.9 to 10.1 volts

c Observe the UNIPOLAR OUTPUT on the scope. Set the Model 2012 SHAPING Switch to 0 5μsec; the output amplitude should be 8.5 to 10 5 volts.

d Measure the UNIPOLAR OUTPUT pulse width at the 100mV points (1% amplitude) They should be within the following ranges. Pole Zero the amplifier for each shaping.

SHAPING	AMP OUTPUT Pulse Width
0 5μsec.	3.4 to 5μsec
2μsec.	11 to 16μsec

5.7 NOISE MEASUREMENT

a. Set the Model 2012 controls as follows

COARSE GAIN:	16
SHAPING	2μsec.

b Put side covers on the Model 2012.

c Connect a "T" connector to the Model 2012 INPUT. Connect the Model 1407 ATTEN OUTPUT cable to the "T" connector. Connect a cable from the other end of "T" connector to the scope input. You will observe a positive tail pulse on the scope. Set the Model 1407 ATTENUATION to X10 and adjust the PULSE HEIGHT until the tail pulse attains an amplitude of 100mV.

d Monitor the UNIPOLAR OUTPUT on the scope and adjust the Model 2012 FINE GAIN until the output amplitude is 10V.

e. Remove the "T" connector and cables from the Model 2012 INPUT. Leave the 93 ohm terminator on the rear panel INPUT. Set the Model 1407 60Hz OFF, 90Hz switch to OFF. Connect the UNIPOLAR OUTPUT to the Noise Meter with RG-62 coax cable and measure the noise. It should be 0.58mV max. for an averaging meter and 0.66mV for a true RMS voltmeter.

5.8 LINEARITY CHECK

One of the simplest and most accurate tests is to set up the system shown in Figure 5.3.

This test is performed by adjusting the pulse attentuator and amplifier gain so that with a ten volt high level (direct) output from the pulser, the output from the amplifier is also exactly ten volts. This may be ascertained by adjusting the pulser attenuator and amplifier gain so that the null point observed on the oscilloscope is at exactly the same level as the baseline with the highest oscilloscope vertical gain.

When this condition is obtained, turn the pulser height control downward from ten volts to the lowest level that will still trigger the oscilloscope and observe the maximum difference between the baseline and the null point. The integral linearity of the amplifier under test is then equal to

$$\frac{(\text{Maximum deviation in volts}) \times 2 \times 100\%}{10 \text{ Volts}}$$

The maximum deviation must thus be less than ± 2.5mV in order to meet the ± 0.05% specification.

The test may be explained as follows. Integral nonlinearity is the maximum deviation from the straight line plotted on an output vs. input plot from zero output to rated output (10 Volts) divided by the rated output stated as a percentage.

This calculation is performed electronically by the test described above by setting

$$\text{OUTPUT} = (\text{K})\ (\text{INPUT})$$

Where K is the pulser attenuation factor and the gain of the amplifier. As the input is decreased the amplifier gain should remain constant (output should decrease linearly), whether or not it does is tested by comparing the output to a signal known to decrease linearly with the amplifier input; the pulser's direct output meets this requirement since it is related to the amplifier input by a passive attenuator. The factor of two must be included because the summing network also serves as a voltage divider decreasing the apparent deviation by a factor of two.

Note that nonlinearity and instability in the pulser output do not enter into the question because both direct and attenuated outputs will be affected identically, save for the negligible effect of the pulser's attenuator instabilities over the short time period required for the test. Instabilities in the baseline level on the oscilloscope are due to oscilloscope triggering and DC level fluctuations and need not be of concern in this test.

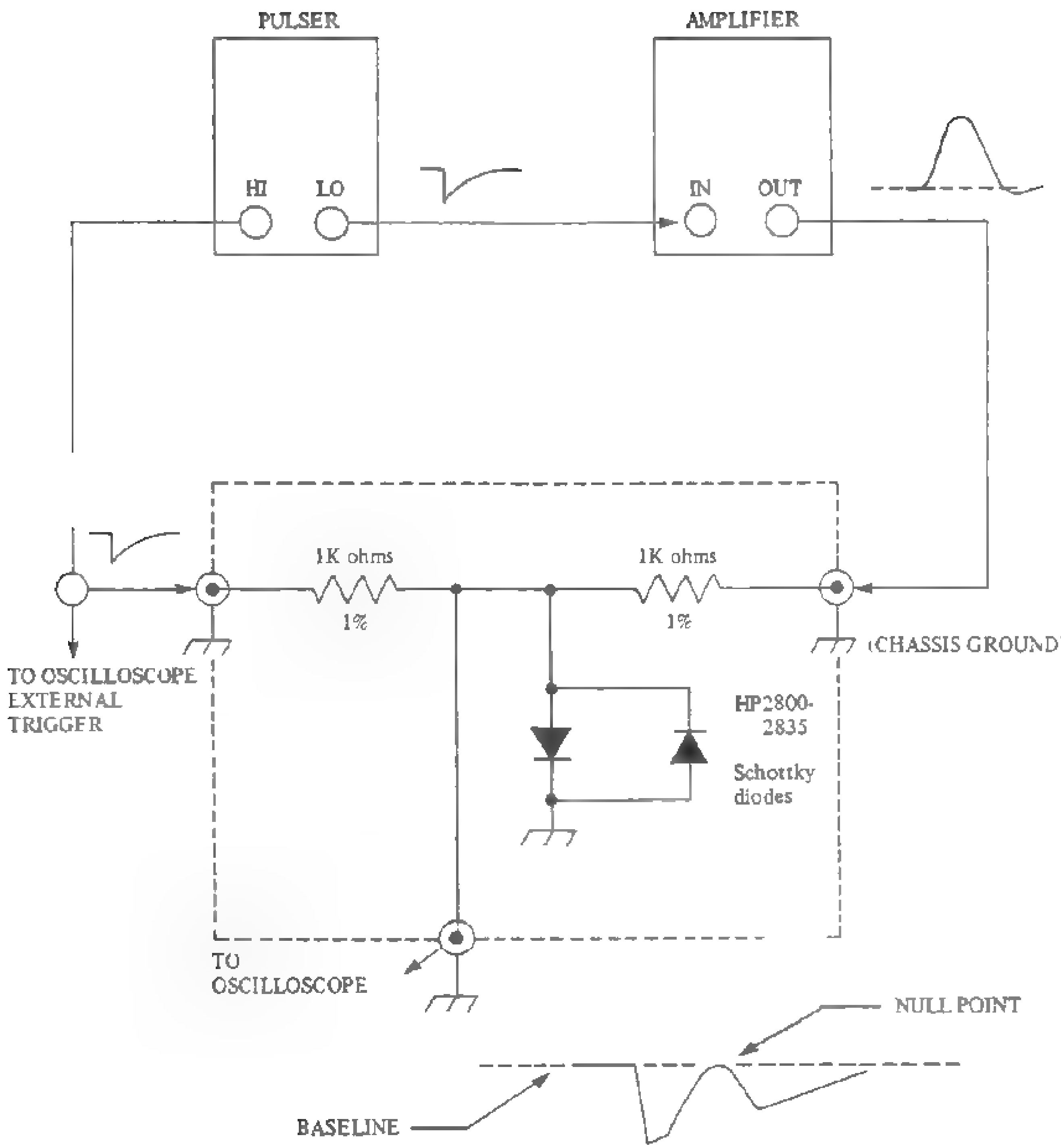


Figure 5.3. Test Setup, Linearity Check

Section 6
THEORY OF OPERATION

6.1 GENERAL

This section of the manual contains a description of the circuitry used in the Model 2012, Amplifier Components are referred to by "reference designations" such as Q2, C5, and R10. Throughout the following circuit analysis, refer to the circuit schematics located in the drawings section.

6.2 BLOCK DIAGRAM DESCRIPTION

The signal flow is as follows

6.2.1 THE AMPLIFIER SECTION

The preamp signal enters either the front panel INPUT BNC (J1) or the rear panel INPUT BNC (J101) where the signal is differentiated, by C1 or C2 and the appropriate amplifier input resistance selected by S2, and pole zeroed by RV1 and R1 or R2. The signal is then amplified by gain amplifiers K1 and K2 Amplifier K1 is either inverting or noninverting depending on the position of switch S2. The amplified signal is next integrated by the first complex pole integrator The integrated signal is used to drive the combination Output amplifier, real pole integrator and DC restorer The processed signal is then connected to the front and rear panel BNC connectors J3 and J102.

6.3 CIRCUIT DESCRIPTION

6.3.1 GAIN AMPLIFIERS

Most of the gain (K1 and K2) is accomplished before the integration occurs. As a result the input amplifier K1 is always the dominant noise source Each of the two gain stages operate at relatively low closed loop gains preventing gain shift with temperature

Amplifiers K1 (Q14 thru Q19) and K2 (Q8 thru Q13) are both basically the same configuration Therefore only K1 will be fully described

The differential input pair Q19 drives the common base transistors Q18 and Q15 Transistors Q18 and Q15 operate at low current levels, providing a high output impedance to drive the output transistors Q17 and Q14 through the common source FET Q16 The necessary current to drive the FET and circuit capacitors at high frequencies is derived directly from the input transistor Q19, through the low impedance of Q18 and Q15. This gives a slew rate for the amplifier of 140 volts per microsecond C12 provides feedback for closed loop stability, and allows the amplifier to follow a 100 nanosecond rise time signal without losing feedback control Since the gain amplifiers do not require DC stability and are operated as inverting amplifiers, a constant current source is not needed in the emitters of Q19 Transistors Q17 and Q14 are biased on by R30 and R33, with the junction of R31 and R33 providing the low impedance output

6.3.2 INPUT AMPLIFIER K1

The first differentiation network, Pole/Zero cancellation circuitry and input polarity selection are located at the input of K1. The SHAPING switch, S3, sections (S1 thru S3) and sections (P1 thru P3) selects the passive differentiator capacitors C1 and C2 and the P/Z compensating resistors R1 and R2 for the selected time constant Pole/Zero control RV1 sets the degree of P Z compensation Input polarity is selected by switch S2 For POS Input polarity, gain is determined by R23 and R15 With NEG Input polarity, the gain is determined by the combination of R23, R15, R12 and R13 Diode D1 is a fast switching protection diode for overload signals

6.3.3 GAIN AMPLIFIER K2

Amplifier K2 is an inverting gain amplifier with its gain controlled by the ratio of the series combination of input resistors R46 thru R51, selected by the COARSE GAIN switch S1a section R1 and the feedback resistor R65 Diodes D3 and D4 provide overload protection Capacitor C35 AC couples the signal to the amplifier summing junction Pot RV2 and resistor R92 form the network in the feedback circuit which controls the FINE GAIN adjustment

6.3.4 INTEGRATOR AMPLIFIER A5

Active integrator A5 provides complex pole pairs which have the locus of the poles equi-distant from the origin. The real part of the complex poles are equal to the pole in the last integrator (Output amplifier A3). The real pole of the differentiator is 1 6 times this value Active filter networks for A5 are selected by the SHAPING switch S3 sections (C1 C2, C3 and E1 E2 and E3) for the desired time constant

Amplifier A5 is a wide band, high slew rate, integrated circuit operation amplifier. It is connected in a non-inverting configuration with a DC gain of 2, determined by R5 and R6

The output of integrator A5 is connected through an RC filter network, R17, R24 and C15, back to the suming junction of gain amplifier K2 for DC stabilization of amplifier K2.

6.3.5 AMP OUTPUT INTEGRATOR AND DRIVER

The unipolar output amplifier is comprised of A3 and a power output driver, Q1, Q2 and Q3 Integrated circuit A3 is a wide band, high slew rate operational amplifier The overall amplifier (op-amp and driver) provides an inverting gain of 2 with single pole integration (C25 and C26) to minimize noise introduced after the integration amplifier A5

The output driver transistors are running Class "AB" Diodes, D11, D14 and current source Q2 keep both output transistors biased on.

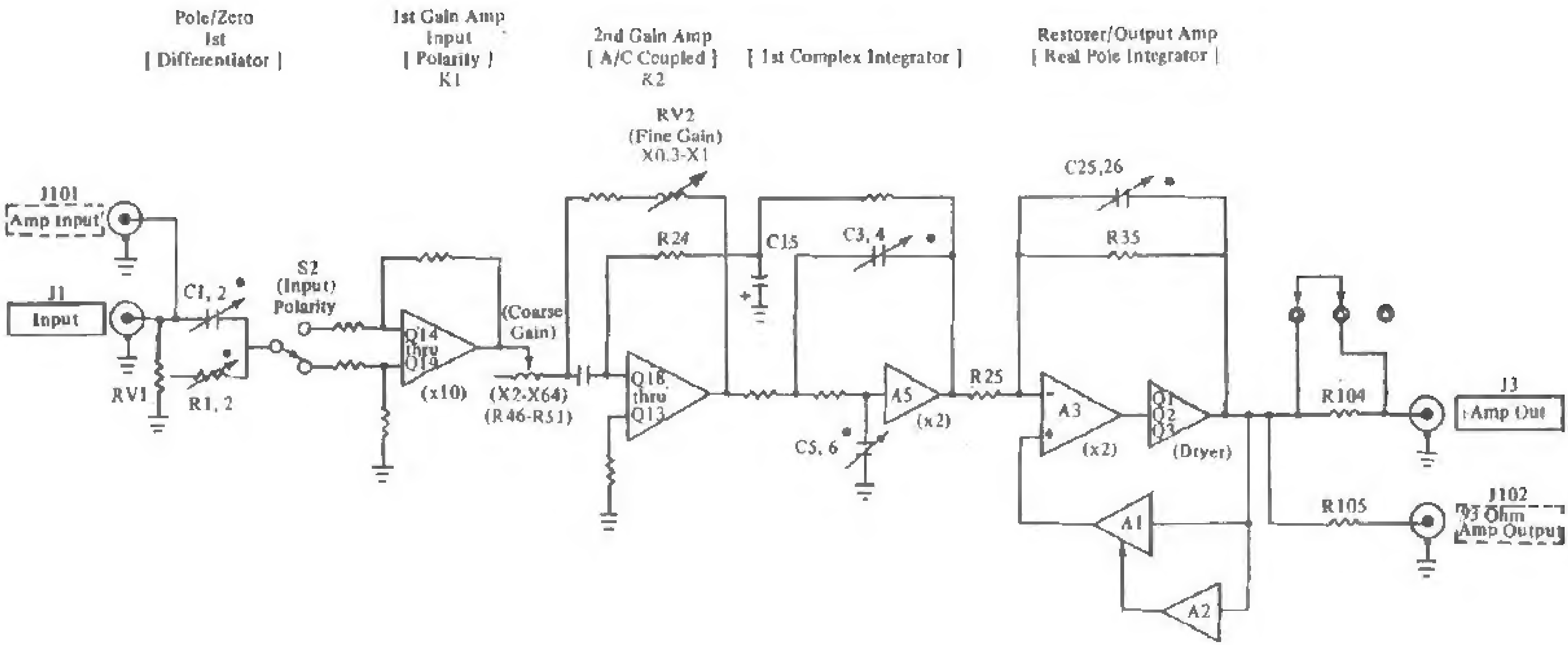
Diodes D12 and D13 provide short circuit protection When a short circuit is connected to the output and the voltage drop across R71 or R72 equals or tries to exceed the diode drops of D12 or D13 (approx. 600mV), diodes D12 or D13 will forward bias and limit the output current to approximately ± 200mA Diodes D9 and D10 provide limiting so that the output transistors do not go into saturation, preventing base-emitter charge storage.

Two UNIPOLAR OUTPUTS are provided The front panel output provides both a low impedance, less than 1 ohm and a 93 ohm, internally selectable by J4 The low output impedance can drive up to 10 feet of 93 ohm coax cable whereas the 93 ohm output can drive hundreds of feet of 93 ohm coax cable The rear panel output has a fixed 93 ohm series-connected output impedance.

6.3 6 RESTORER

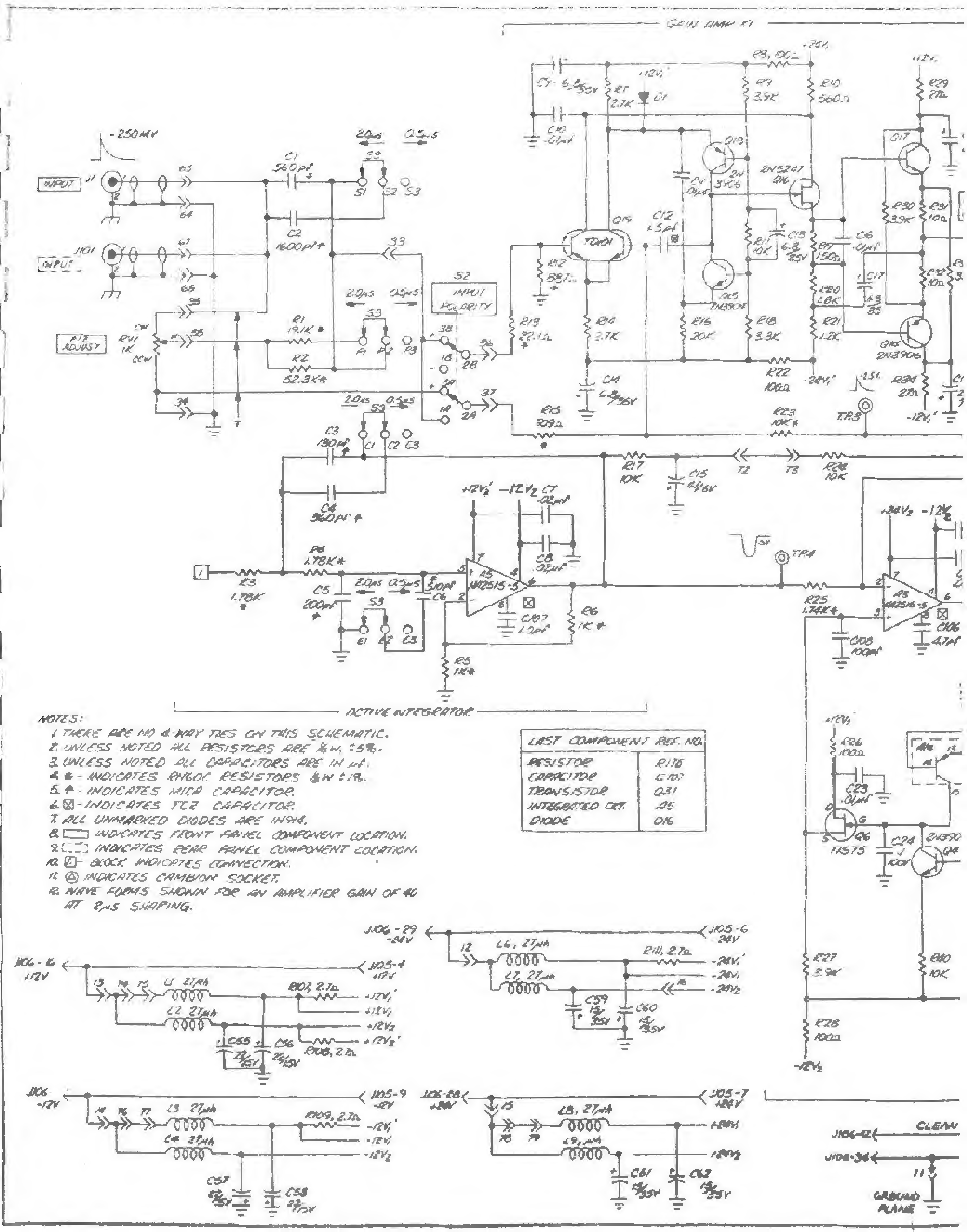
The restorer circuitry consists of the output amplifier A3 transistor array A1, a dual differential comparator A2 and transistors Q4 thru Q7 and Q29 and Q30. The restorer is a transconductance type amplifier, that is, it monitors the output voltage of the UNIPOLAR OUTPUT (TP1) and develops a constant current of the correct polarity at its output (junction of Q4 collector and A1e pin 5), this generates a voltage on C24 which is to the suming junction of gain amplifier K2 for DC stabilization of amplifier K2 (TP1) to 0 volts maintaining the baseline When A2 detects a signal, its output causes Q29 to turn off. Q7 switches on a current sufficient to back bias current source 1a of A1 which disables the restorer Capacitor C40 AC couples to transistor Q29 preventing any restorer latch up problems. The UNIPOLAR OUTPUT signal (TP1) is clamped by diode network D15 and D16 and connected to the comparator input A2 pins 5 and 2

The negative restorer gate threshold is set at - 100mV by resistors R103 and R100. The positive threshold is variable and dependent on the setting of the coarse gain switch S1b and resistors R94 thru R99. Pot RV3 adjusts the offset of the restorer output and UNIPOLAR OUTPUT (TP1) to ground.



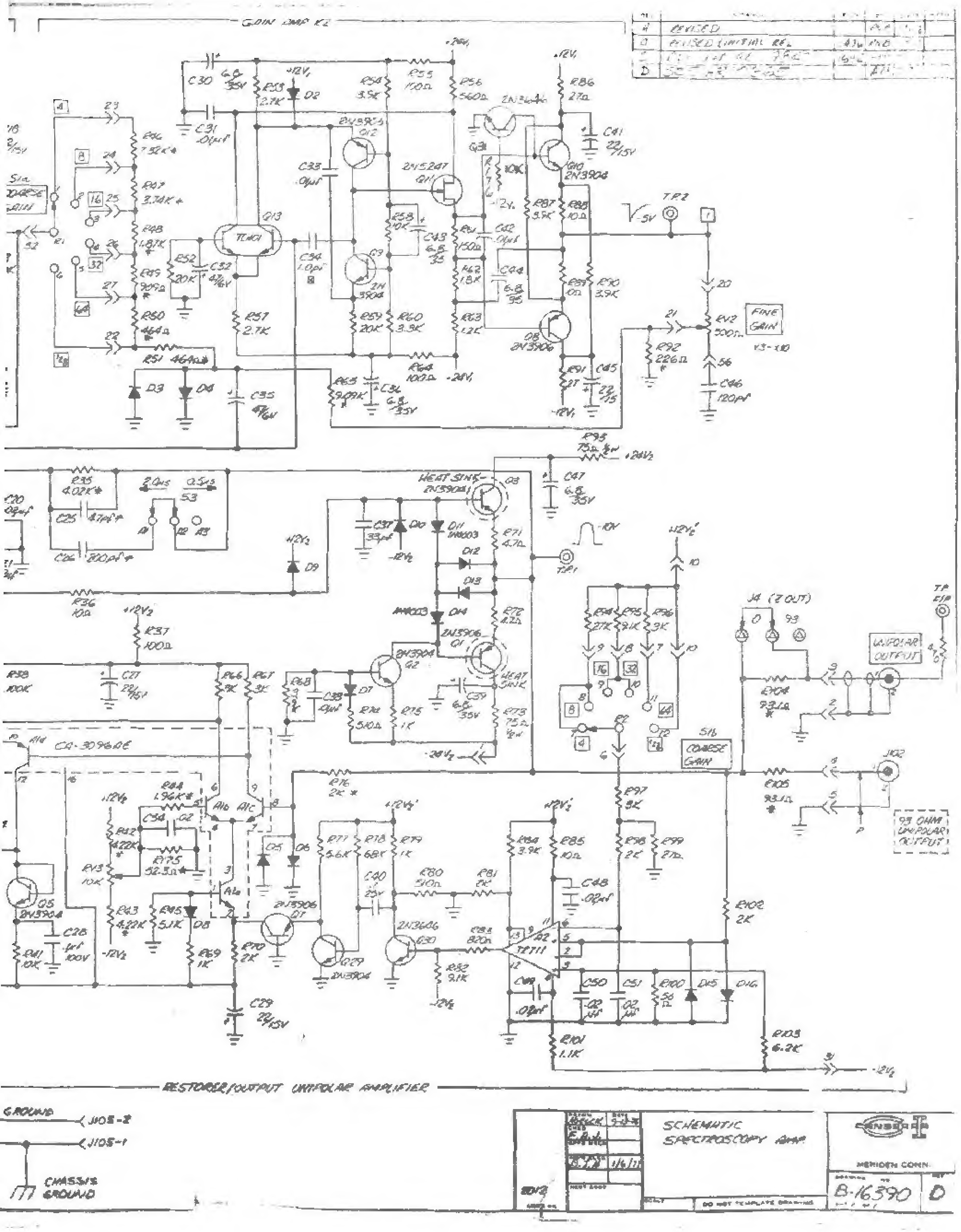
NOTES:
1. • - Indicates a Simultaneous Change (Shaping Switch).
2. ⊙ - Indicates a Cambion Socket.
3. ▭ - Indicates a Front Panel Component
4. ⬚ - Indicates a Rear Panel Component.

Figure 6-1. AMP/SCA Model 2012



NOTES:
1. THERE ARE NO 4-WAY TIES ON THIS SCHEMATIC.
2. UNLESS NOTED ALL RESISTORS ARE ¼W, ±5%.
3. UNLESS NOTED ALL CAPACITORS ARE IN µf.
4. ✱ - INDICATES RN60C RESISTORS ⅛W ±1%.
5. ✦ - INDICATES MICA CAPACITOR.
6. ⊠ - INDICATES TCZ CAPACITOR.
7. ALL UNMARKED DIODES ARE IN914.
8. ▭ INDICATES FRONT PANEL COMPONENT LOCATION.
9. ┄ INDICATES REAR PANEL COMPONENT LOCATION.
10. [1]- BLOCK INDICATES CONNECTION.
11. Ⓐ INDICATES CAMBION SOCKET.
12. WAVE FORMS SHOWN FOR AN AMPLIFIER GAIN OF 40 AT 2µS SHAPING.

LAST COMPONENT REF. NO.	
RESISTOR	R110
CAPACITOR	C107
TRANSISTOR	Q31
INTEGRATED CKT.	A5
DIODE	D16



A	REVISED		
B	REVISED (INITIAL REL.)		
C	[illegible]		
D	[illegible]		

SCHEMATIC SPECTROSCOPY AMP

MERIDEN CONN.

DO NOT TEMPLATE DRAWING

B-16390 D